MODEL-BASED GLYCAEMIC CONTROL IN CRITICAL CARE

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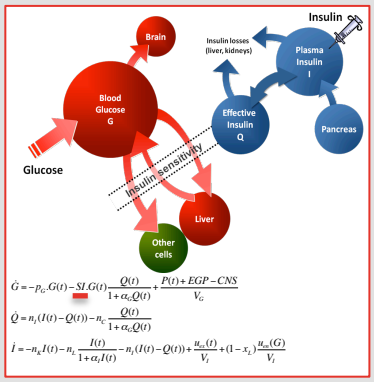
Introduction

- High and variable blood glucose (BG) levels have been associated with increased morbidity and mortality in critically ill patients.
- Model-based glycaemic control uses a physiological model of the glucose-insulin system to enable patient-specific control of blood glucose concentrations.
- By fitting certain model parameters, model-based controllers can tailor interventions to the metabolic state of each individual patient as it changes over time.
- STAR is a successful model-based protocol that has been developed and tested collaboratively in New Zealand, Belgium and Hungary.

Methods & Results

The STAR Protocol



$$\dot{G} = -p_G \cdot G(t) - SI \cdot G(t) \frac{Q(t)}{1+\alpha_G Q(t)} + \frac{P(t) + EGP - CNS}{V_G}$$

$$\dot{Q} = n_1 (I(t) - Q(t)) - n_C \frac{Q(t)}{1+\alpha_G Q(t)}$$

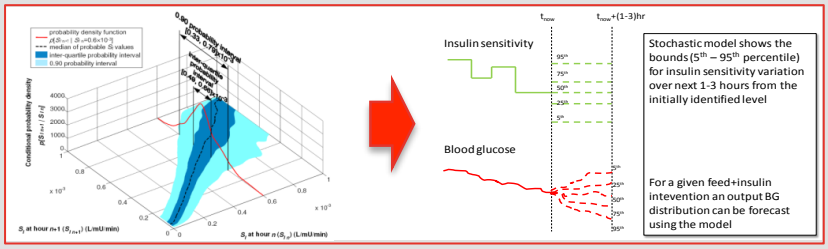
$$\dot{I} = -n_K I(t) - n_L \frac{I(t)}{1+\alpha_I I(t)} - n_1 (I(t) - Q(t)) + \frac{u_{ex}(t)}{V_I} + (1-x_L)\frac{u_{en}(G)}{V_I}$$

STAR is a model-based controller using a compartment model of the glucose-insulin system. This model uses a time-varying insulin sensitivity parameter (*SI*) to capture the patient-specific response to insulin and glucose.

STAR is implemented on a tablet computer, with a user interface developed in conjunction with nursing staff in all three countries.

STAR has been successfully implemented in 3 ICUs in NZ, Belgium and Hungary with very different clinical practices and requirements.

STAR uses a kernel density model based on historical data to estimate the expected range of response behavior during the forthcoming hours. This stochastic forecasting enables the risk of hypoglycemia to be quantified and managed for each proposed intervention.



	STAR Chch	STAR Gyula	STAR Liege
Workload			
# BG measurements:	1,948	622	91
Measures/day:	***12.4***	***12.8***	***11.3***
Control performance			
Target band (mmol/L)	4.4 - 8.0	4.4 - 8.0	5.6 - 7.8
BG median [IQR] (mmol/L):	6.1 [5.6 - 6.8]	6.0 [5.4 - 6.8]	7.4 [6.5 - 8.4]
% BG in target range	***89.4***	***80.4***	***54.9***
% BG > 10 mmol/L	3.0	2.2	7.7
Safety			
% BG < 4.0 mmol/L	***0.9***	***2.4***	***1.0***
% BG < 2.2 mmol/L	0	0	0
# patients < 2.2 mmol/L	***0***	***0***	***0***
Clinical interventions			
Median insulin (U/hr):	3.0	2.5	2.0
Median glucose (g/hr):	4.9	4.4	0

Summary

The STAR model-based glycaemic control protocol for critical care was developed in collaboration between researchers in NZ, Belgium and Hungary. To date, the results and safety have been excellent.

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